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Photoconductivity for Silver Nitrate in Nanostructured Sol–Gel Materials

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We report on the photoconductive response of nanostructured sol–gel films in function of the silver nitrate concentration (ions and colloids). Silver colloids were obtained by spontaneous reduction process of Ag^+ ions to Ag^0. 2-d hexagonal nanosructured sol–gel thin films were prepared by dip-coating method using the non-ionic diblock copolymer Brij58 to produce channels into the film, which house the silver nanoparticles. An optical absorption band located at 430 nm was detected by optical absorption; it corresponds to the surface plasmon. A fit to this band with modified Gans theory is presented. Photoconductivity studies were performed on films with silver ions and films with silver colloids to characterize their mechanisms of charge transport in the darkness and under illumination at 420 and 633 nm wavelengths. The films with silver colloids exhibit a photovoltaic effect stronger than the films with silver ions. While a photoconductive behaviour is observed in the films with silver ions.

Keywords: Sol–Gel, Photoconductivity, Silver Colloids, Surfactant.

RESEARCH ARTICLE

1. INTRODUCTION

Optical properties of silver nanoparticles embedded in dielectric media are interesting because of their technological applications in photo electrodes for solar cells,[1] optical switches[2] and electronic properties.[3]

Nanoporous silica materials have been doped with metal nanoparticles to modify their properties and to obtain unique properties.[4] These materials have applications in nanotechnology as sensors, catalysts, etc.[5] Much effort has been devoted to prepare silver nanoparticles in both organic and inorganic materials. The use of inorganic oxide coatings rather than organic stabilizers provides several advantages.[4] The nanostructured sol–gel thin films prepared with poly(ethylene oxide)-based non-ionic diblock ($C_nH_{2n+1}(OCH_2CH_2)_yOH$) copolymers, contain three distinct regions (Fig. 1): the framework that consists of silica or modified silica, the shell that is formed by the hydrophilic part of the surfactant (EO blocks which are water soluble) with residual solvent, and the core that is formed by the hydrophobic part of the surfactant. We used a non-ionic diblock surfactant, Brij58 ($C_{16}H_{33}(OCH_2 \cdot CH_2)_{20}OH$), to create a long-ordered nanostructure in the thin films. The micelles possess a hydrophobic core are surrounded by an outer shell of the EO blocks.

Nanostructured sol–gel thin films were doped with silver nitrate under acidic conditions. The structure was identified by X-ray diffraction and TEM. Photoconductivity studies under illumination and in the darkness were done in both thin films, with Ag^+ ions and silver colloids (metallic Ag^0 nanoparticles). The reduction of Ag^+ ions to silver colloids was detected by the typical sequence of color changes from colorless/white to black. The reduction process was monitored by UV-VIS absorption spectroscopy. A black silica thin film usually displays a plasmon band around 450 nm. The optical absorption band of the resonance plasmon was fitted using a modified Gans theory at different concentrations of $AgNO_3$/Brij58. In this paper, we report a theoretical model with concentration dependence to fit the conductivity on these films when ions or metallic particles are present.

2. EXPERIMENTAL DETAILS

Glass substrates were cleaned in an acidic solution of sulphuric acid/H_2O_2 (4:1) and heated and stirred for 0.5 h. They were then placed in deionized water and boiled for 0.5 h, rinse three times with deionized water, and stored in deionized water at room temperature. Films were dip coated to the glass substrates (9 cm × 1 cm × 1 cm) at rate of 3.5 cm/min using the apparatus shown in Figure 2. The films were drawn with the equipment

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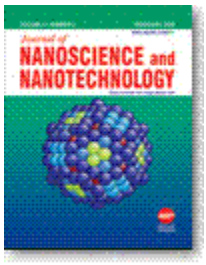

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Abstract:

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